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**(54) Title:** A MULTIPLE DIP PROCESS FOR MAKING A POWDER-FREE ARTICLE

**(57) Abstract**

The present invention involves a process of making a powder-free rubber article using a multiple dip process. The process comprises the steps of: a) dipping a former of the desired shape of the article into a composition consisting essentially of an aqueous acrylic ester latex and water soluble salts capable of coagulating a rubber latex; b) dipping the former in step (a) into a rubber latex to produce a second layer; c) leaching the second layer in water; d) curing the first and second layers; and e) stripping the resultant article from the former. The acrylic ester latex is a water insoluble polymer emulsion in water. The polymer is composed predominantly of acrylic ester groups which make up at least 50 % by weight of the polymer.

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## A MULTIPLE DIP PROCESS FOR MAKING A POWDER-FREE ARTICLE

FIELD OF THE INVENTION

The present invention relates to a process of making a powder-free rubber article. More specifically, the present invention relates to a process of making powder-free articles, particularly 5 gloves, using a multiple dip process.

BACKGROUND OF THE INVENTION

Traditionally, rubber articles such as gloves were manufactured by dipping a former or mold into a rubber latex. These processes often included the use of a 10 powdered lubricant, such as talc, cornstarch, or clay. Typically, the powder was incorporated into either a coagulant or into a release slurry. A coagulant is a compound that coagulates a layer-forming emulsion or dispersion to form a thicker layer than it would 15 normally do otherwise. A release slurry is a slurry containing powder which is applied to the article prior to removal from the former. The use of powder in the coagulant or release slurry served two important purposes. First, powder made it easier to strip the 20 resulting article from the former. With respect to gloves, removal from the mold is often difficult because cured latex gloves tend to be tacky and adhere to the mold. However, the use of powder reduced the tackiness or stickiness of the gloves and improved

stripping. Second, powder facilitated donning in certain articles such as gloves.

While the use of powder in the manufacture of rubber articles solved many problems, it created many 5 new ones as well. The main problem was that the completed rubber article contained a great deal of residual powder. It is well known in the art that this residual powder can create numerous problems, particularly with respect to surgical gloves where 10 there is a risk that the powder may escape from the glove and contaminate the surgical field. See Alexander's Care of the Patient in Surgery 9th Edition. Another problem commonly associated with the use of powder is that the process requires cleaning up the 15 powder residue on the former after formation of each and every article, a tedious and time consuming operation. Because of these problems, numerous attempts have been made to eliminate the use of powder in the construction of articles. For a detailed 20 description of making rubber articles see: Natural Rubber Dipping Technologies, Symposium on Latex as a Barrier Material, April 6 and 7, 1989, University of Maryland; Russell D. Culp and Bradley L. Pugh. This publication is incorporated herein by reference.

25 Several processes are known in the art for making powder-free articles.

PRIOR ART

In one process to make the article powder-free, the article is halogenated, normally with chlorine, in a batch process. For example, U.S. Patents 3,411,982 and 3,740,262 disclose that the surface of a rubber glove can be halogenated to make it slippery. U.S. Patent 4,304,008 discloses that halogenation facilitates donning in rubber articles in lieu of powdered lubricants. U.S. Patent 3,740,262 discloses 10 halogenating a glove to provide a powder-free rejecting outer surface and a powder-accepting inner surface.

Halogenation produces articles having a powder-free clean surface. In fact, chlorination is widely used to make clean-room gloves, powder-free surgical 15 gloves and powder-free examination gloves. Although articles produced using chlorination are powder-free and exhibit good dry donning characteristics, they are economically more expensive to produce due to the number of chlorination steps, turning steps, and drying 20 processes involved in the manufacture.

While halogenation can be used to facilitate donning, halogenated articles possess many disadvantages. Halogenated articles tend to discolor and age poorly both in storage and in use. In fact, 25 discoloration can begin almost immediately, and within a month, the halogenated surface may become hard and brittle and brown in color. Additionally, chlorine is

considered to be a toxic chemical and disposal of materials containing this element presents numerous environmental issues.

The disadvantages of chlorination are recognized 5 in U.S. Patent 5,284,607. This patent discloses a process for making a multi-layered, powder-free medical glove. The glove is made with an acid-soluble powder, and once fully formed, stripped from the former and reversed so that the first layer is on the outside. 10 The glove is then treated with an acid, such as nitric acid, to remove the acid-soluble powder. After the acid treatment, the glove is rinsed with water and treated with bleach to chlorinate the inner and outer glove surface. The bleach does not cause the glove to 15 have the excessively slippery outer surface that typically results when chlorination is used.

U.S. Patent 4,310,928 discloses a talc free surgeon's glove. The glove is made by dipping a former into a coagulant solution containing a lipo compound 20 and a surfactant and then into latex to form a glove.

U.S. Patent 4,499,154 discloses another method of making a powder-free article. This patent details a process for making a rubber article by dipping a former into compounded latex, leaching the article, priming 25 the article with an acid, neutralizing the article with water or an aqueous alkali, applying a hydrophilic coating, heating the article to fix the coating, curing

the rubber, stripping the article from the former and applying a solution of surfactant materials and silicone. While this process produces a powder-free article, the number of steps involved makes the process 5 unduly expensive and the low molecular weight components (surfactants and silicone) could cause contamination.

U.S. Patent 5,138,719 discloses a method of making powder-free gloves, finger stalls and other protective 10 articles constructed from latex and microcapsules. The microcapsules are dispersed and arranged in the latex to form a concentration gradient, with the concentration of the microcapsules increasing progressively from the outer surface to the inner 15 surface of the article. The high concentration of the microcapsules at the inner surface provides good sliding properties and facilitates donning without the need for powder. In addition, the microcapsules may contain a pharmaceutically active substance such as 20 nonoxynol, moroxydine hydrochloride, vidarabine to provide viricidal activity against diseases such as AIDS or herpes. See U.S. Patent 5,024,852.

EP 0574160A1 discloses a method for making a powder-free, wet and dry donnable, multi-layered 25 article having a first layer formed from natural rubber, a second layer formed from natural rubber, polyurethane, poly(acrylamide/acrylic acid) and

polyethylene oxide, and a third layer of an acrylic copolymer and fluorocarbon telomer resin.

U.S. Patent 3,411,982 discloses a method for making an elastomeric article having a slip coating.

5 In one embodiment, the method involves first dipping a former into talc or some other releasing agent which leaves a powder residue. The former is next dipped into a slip dip compound made of a rubber-resin compound that contains a coagulant and a stabilizing 10 surfactant. The former is removed from the slip dip compound and allowed to dry. Once dried, the former is dipped into latex to form the desired article. After dipping in the latex, the former is withdrawn and leached in water. After leaching, the article is dried 15 or cured and then stripped from the former. Articles produced according to the above process, while multi-layered, are not powder-free.

A different process for making rubber gloves alleged to have good donning properties is disclosed in 20 Kavalir et al., U.S. Patents 3,286,011 and 3,411,982. The disclosures of these patents are the same. These patents a coating composition comprising a mixed latex which is approximately 1:1 on a weight basis of a rubber latex and certain resinous polymer latices. One 25 group of these polymer latices are certain acrylic ester latices. The compositions of the patent are suggested for use as being former coatings and as

coatings for the inner surfaces of rubber gloves to impart improved donning characteristics. The acrylic ester latices used by the patentees in their process are mixtures of acrylic ester latices. These acrylic 5 latices and their method of manufacture are described in detail as well in U.S. Patent 2,795,564 the disclosure of which is incorporated herein by reference.

One of the teachings of the Kavalir et al. patents 10 is that high concentrations of coagulating salts may be incorporated into the coating compositions of the invention. The use of a water soluble non-ionic surfactants incorporated into the compositions of the patent allows for the introduction of large quantities 15 of coagulating salts such as calcium nitrate without resulting in the destabilization of the compositions. The patentees stress that the resinous polymer latices alone without the rubber latex are inoperative. Other disadvantages become apparent from the study of these 20 patents. Powders such as talc, are needed to provide former release. Also, the compositions of the patentees are high solids viscous compositions making them difficult to apply either to formers or articles formed thereon. Thus, while providing an interesting 25 approach to improved glove making this patent still does not solve the problem of eliminating powders as lubricants.

OBJECTS OF THE INVENTION

An object for the present invention is to provide a simplified process of making powder-free articles, particularly gloves, using multiple dip coating

5 technologies with carefully engineered functional inner and outer layers. Articles made in this manner can be produced in a continuous fashion, with substantial economic savings, and added features and benefits. In addition, environmentally friendly materials and

10 processes can be used if water borne systems are selected for use in conjunction with this process.

Importantly the invention provides for good release of the articles from the formers upon which they are produced. In the case of gloves produced by the

15 process of the invention exhibit excellent dry and some good wet donning characteristics.

SUMMARY OF THE INVENTION

The present invention provides a process of making a powder-free rubber article using a multiple dip process. In particular, this process can be used to

20 make powder-free articles such as surgical and examination gloves, catheters and condoms. The method disclosed in this application may be used in other medical applications such as in the construction of

25 surgical operative fields, finger stalls, aprons, bibs, and caps.

The invention comprises a multiple dip process for making powder-free rubber articles, particularly gloves. It comprises the steps of:

- a) dipping a former of the desired shape of the article into a composition consisting essentially of an aqueous acrylic ester latex and water soluble salts capable of coagulating a rubber latex. The acrylic ester latex is a water insoluble polymer emulsion in water. The polymer is composed predominantly of acrylic ester groups which make up at least 50% by weight of the polymer. The dip into the acrylic ester latex causes a first layer lubricating coating to be formed on the former.
- 10 b) dipping the former treated in step (a) into a rubber latex to produce a second layer;
- c) leaching the second layer in water;
- d) curing the first and second layers; and
- e) striping the resultant article from the former.

20 The process thus described may be modified by the additional step of applying the composition described above which does not contain the water soluble salts to the second layer prior to curing. It may be further modified by the additional step of applying the composition to the article prior to stripping, but 25 after curing, and then drying.

The aqueous acrylic ester latex preferably is an

acrylic acid or methacrylic acid ester latex which is synthesized from acrylate esters containing from 4 to 22 carbon atoms. In another desirable embodiment, the aqueous acrylic ester latex is a copolymer which 5 contains from 2-3 monomers. It may be a mixture of acrylic esters. In another preferred embodiment of the invention the acrylic esters contain from 0.1 to 20 weight percent of either acrylic or methacrylic acid.

Additionally, improved mold release 10 and donning characteristics are achieved when the acrylic ester latices described above are combined with from 0.001 to 3% by weight of a silicone resin.

The invention is also directed to formers of the type used to make gloves and similar articles which 15 contain an easy release coating of the compositions described above. It also relates to gloves and similar articles having on their inner surfaces a coating of the compositions of the invention which do not contain the water soluble rubber latex coagulating salts which 20 coatings provide good donning properties.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a multiple dip process for producing a powder-free rubber article. As used in the specification and appended claims, "powder-free" means that the article has been manufactured to 25 eliminate most, if not all, of the powder on the

surface of the article.

To produce a powder-free article, a cleaned former or mold in the shape of the desired article is first dipped or immersed into a coagulation inducing, powder-free composition to form a coagulation inducing film.

5 The coagulation inducing, powder-free composition functions as a coating thereby eliminating the need for a powdered coagulant. The coagulation inducing, powder-free composition is an acrylic latex that 10 contains coagulant salts. Methods for making polymer dispersions or emulsions are well known in the art.

15 See Blackley, High Polymer Latices Vol. 1 and 2, MaClaren & Sons, Ltd., 1966, pgs. 266-270. Acrylated ester latex preparations are described in detail in U.S. Patent 2,795,564. The acrylate ester latices contemplated for use in the coagulation inducing, powder-free composition are those polymers which will provide a good coating, eliminate the need for powder, will not block and will not stick to itself or other 20 substrates. Additionally, it is also important that these latices have sufficient electrolyte stability to accommodate the coagulant salts used in the formulation. As used in this specification, "electrolyte stability" means that the polymer 25 suspension does not destabilize when the coagulant salt is added. The electrolyte stability can be determined by adding coagulant salts to the polymer suspension and

observing whether the polymer destabilizes. If destabilization occurs, chunks of the polymer are observed floating or settling in the dispersion or emulsion. See Blackley, p. 27. The stability of the 5 acrylate ester latex containing the coagulant salts can be improved by combining therewith stabilizing amounts of surfactants, particularly non-ionic surfactants as described in the Kavalir et al. patents.

An important modification that may be used to 10 improve the anchorage of the acrylate ester polymers is to incorporate into these polymers between about 0.01-10% by weight of an allyl acrylate. Preferably the amount of the allyl acrylate is between 1-5% by weight.

15

#### The Acrylic Ester Latices

The latices may be prepared by homo or copolymerizing one or more acrylic esters. The polymerizations are performed in the presence of free radical catalysts which are described and illustrated 20 in the references previously cited. The acrylic esters that may be used may be either acrylic acid esters that produce soft or hard polymers.

As polymerizable, neutral monomeric monovinylidene esters which form soft, solid polymers in the presence of peroxidic catalysts, there may be used any primary 25 and secondary alkyl acrylate, even with alkyl substituents up to eighteen or more carbon atoms,

primary or secondary alkyl substituents of five or eighteen or more carbon atoms, or other monovinylidene compounds as defined above which are polymerizable below 80°C. with free radical catalysts to form soft 5 solid polymers. Ionically polymerizable compounds are not within the scope of this class of compounds. The preferred monovinylidene compounds are the stated acrylates and methacrylates and of these the most practical esters are those with alkyl groups of not 10 over 12 carbon atoms.

The preferred monomers which by themselves yield soft polymers may be summarized by the formula



15 where R is hydrogen or the methyl group and  $R^x$  represents, when R is methyl, a primary or secondary alkyl group of 5 to 18 carbon atoms, or, when R is hydrogen, an alkyl group of not over 18 carbon atoms, 20 or better, of two to 12 carbon atoms.

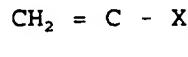
Typical compounds coming within the above definition are methyl acrylate, ethyl acrylate, propyl acrylate, isopropyl acrylate, butyl acrylate, isobutyl acrylate, sec.-butyl acrylate, amyl acrylate, isoamyl 25 acrylate, hexyl acrylate, 2-ethylhexyl acrylate, octyl acrylate, 3,5,5-trimethylhexyl acrylate, decyl acrylate, dodecyl acrylate, cetyl acrylate, octadecyl acrylate, octadecenyl acrylate, n-amyl methacrylate,

sec-amyl methacrylate, hexyl methacrylate, 2-ethyl  
methacrylate, octyl methacrylate, 3,5,5-trimethylhexyl  
methacrylate, decyl methacrylate, dodecyl methacrylate,  
octadecyl methacrylate, butoxyethyl acrylate or  
5 methacrylate or other alkoxyethyl acrylate or  
methacrylate, etc.

As polymerizable monovinylidene monomers which by  
themselves form hard polymers, there may be used alkyl  
methacrylates having alkyl groups of not over four  
10 carbon atoms, also tert.-amyl methacrylate, tert.-butyl  
or tert.-amyl acrylate, cyclohexyl acrylate or  
methacrylate, acrylonitrile, or methacrylonitrile.

The above monomers yield polymers under the  
influence of free radical catalysts, particularly  
15 peroxidic catalysts, which polymers are generally  
regarded as hard. These polymers when free of any  
appreciable content of monomer, have Tg values above  
about 20°C. Hard polymers have also been defined as  
those having softening points above 55°C or brittle  
20 points above about 5°C. These are all different  
appraisals of the force required to produce a given  
deformation in a body in a given time and to evaluate  
the aggregation of various properties encompassed  
within the term of hardness.

25 Preferred monomers which by themselves form hard  
polymers may be summarized by the formula



## R

wherein R is a hydrogen of the methyl group and wherein X represents one of the groups -- CN, and ester-forming groups -- COOR', wherein R' is cyclohexyl or, 5 when R is hydrogen, a tert.alkyl group of four to five carbon atoms, or, when R is methyl an alkyl group of one to four carbon atoms. Some typical examples of these have already been named. Other specific compounds are methyl methacrylate, ethyl methacrylate, 10 propyl methacrylate, isopropyl methacrylate, butyl methacrylate, sec.-butyl methacrylate, and tert.-butyl methacrylate.

When the hard acrylic esters are used in the practice of the invention they tend to form brittle 15 films. To render the films of these polymers more flexible it is beneficial that they be polymerized with other monomers to render them less brittle when subject to forces of stretching, crushing and the like. These hard acrylic esters may be improved in their properties 20 by copolymerizing them with soft acrylate esters or other monomers. Even in the case of the soft acrylate ester latex polymers benefits may be derived by incorporating into the structure of these polymers other monomers that improve their film forming and 25 lubricating effectiveness. One of the most beneficial group of monomers that may be copolymerized with acrylate esters are the acrylic acids.

The Acrylic Acid Monomers

As indicated these monomers are incorporated into the acrylic ester latices used in the practice of the invention in amounts ranging from between 0.1 - 20 % by 5 weight. The amount to be used will depend on the properties of the acrylic ester latex with which they are polymerized. Optimization can be determined by the use of routine experimentation.

The preferred acids are methacrylic and then 10 acrylic. In place of the free acids there may be used water-soluble salts thereof, including the ammonium salts and the alkali metal salts such as lithium or potassium carboxylates. The salts may be preformed or they may be formed in the dispersion system. The 15 necessary and important consideration is that carboxylate groups be supplied to enter into the interpolymer. The best way to ensure that carboxylate groups do in fact enter into the copolymer chain is to use an above acid.

20

Other Monomers

While acrylic acid or methacrylic acid and their salts may be used to modify the acrylic ester latices to improve their usefulness other modifications of the acrylic ester latices may be made. It is well known 25 that acrylate ester latex homo and copolymers may be polymerized with a variety of monomers to change the

physical properties of these polymers. When such additional monomers are copolymerized with the acrylic esters they should be used in amounts that do not change the basic characteristic of the acrylate esters.

5 Highly polar monomers such as acrylamide must be used judiciously to avoid converting the acrylic ester latices from their normal state of water insolubility to water solubility or dispersability. Usually when polar vinyl monomers are used as modifiers for the 10 acrylate ester latices they should rarely exceed 20 % by weight. Preferably they should not exceed 10% by weight.

Other monomers may be polymerized with the acrylic esters to provide different properties to the finished 15 latex. For instance plasticizers may be built into the acrylic ester polymers by using up to about 5% of a vinyl glycol ester. In a similar fashion improved lubricity may be achieved by incorporating into the acrylic ester polymers from 0.1 to about 10% by weight 20 of copolymerizable surfactants such as polar fatty compounds. Alternatively, surfactant type molecules can be introduced by the ethoxylation of the acrylic esters when they contain active hydrogen atoms capable of reacting with ethylene oxide. Another useful 25 modification of the acrylic ester latices is to incorporate up to as much as 20% of hydroxy alkyl esters of either acrylic or methacrylic acids.

Mixed Acrylic Ester Latices

As indicated it is also within the scope of the invention to use physical mixtures of two or more acrylic ester latices for the purposes of the 5 invention. Routine experimentation may be used to optimize such blends for purposes of the invention. Blends of acrylic ester latices are shown in U.S. Patent 2,795,564, which has previously been discussed.

Silicone Polymer Modification of the Acrylic Ester Latices

Improved results are achieved when the acrylic ester latices are modified to include silicone polymers. A variety of methods have been shown for combining silicones with acrylic esters. See U.S. 15 Patent 5,202,368, the disclosure of which is incorporated herein by reference. A preferred method of combining the silicone resin with the acrylic ester latex is to use silicone emulsions which contain in emulsion form silicone polymers such as 20 polydimethylsiloxane polymers. One such emulsion is sold by Dow Corning under the trade designation, Dow Corning Silicone Emulsion 365. While the amount of silicone resin on a dry weight basis may range between 0.001 to 3% by weight typically 0.1 to 2.5% will give 25 good results. Amounts as great as 5% may be used but too much may produce adverse effects. These emulsions

may require modification to render them compatible and stable when they are blended with the acrylic ester latices.

Working Concentrations of the Acrylic Ester Latices:

5 Blending with the Coagulant Salts: Film Thickness

The acrylic ester latices are produced commercially in the form of concentrates which contain at least 20% and often in excess of 35% by weight of the acrylate ester polymer. It has been found that 10 these concentrated latices in many cases do not provide good quality mold or article coatings. In a preferred mode of the invention it has been found that good 15 coatings are obtained when the latices are diluted with water to provide latices containing between 2-10% by weight of the acrylate ester polymers. Concentrations of between 4-8%, most preferably 6%, give good results.

In order to provide an improved commercially workable process which provides good former release and at the same time simplify coagulation of the rubber 20 latex it is necessary that the diluted acrylic ester latex be fortified with at least 5-25% and preferably 10-20% by weight of a coagulating salt. These coagulating salts are most commonly inorganic salts of mineral acids such as the water soluble alkaline earth 25 salts of hydrochloric, sulfuric or nitric acids.

Typically salts such as calcium chloride or calcium

nitrate provide satisfactory coagulation of most rubber latices. Salts of zinc and aluminum may also be used.

The salts when added to the acrylic ester latices in certain instances cause destabilization of the 5 latex. To prevent this from taking place it is desirable that a stabilizing amount of a water soluble surfactant, preferably a non-ionic surfactant be added to the latex-salt mixture. This stabilization technique is described in the Kavalir patents 10 previously cited. The amount and type of surfactant can only be determined by experimentation since the latex and particular coagulant salt will vary. Usually not more than a few percent of the stabilizer is necessary e.g. about from 0.1% to about 3% by weight. 15 It will be understood that when the acrylic ester latices are used to form a coating on the inside of the finished article such as a glove it is not necessary nor desirable that the latex contain a coagulating salt. In a similar fashion it not necessary that the 20 same latex used as the former mold release coating be used in the formation of the donning coating.

The thickness of the coatings applied to the former or to the formed article will vary and can be optimized by routine experimentation. The thickness of 25 the former release coating need not necessarily be the same thickness as a donning coating. As a general rule the thickness of the coatings should not be not be

greater than 20% the thickness of the coating of the rubber latex article. Typically coatings as thin as 200 microns up to coatings of several mils may be used.

5

### The Coating Process

Once the coagulation-inducing, powder-free composition is prepared, the former is dipped or immersed in the composition to form a film or first layer and is then withdrawn. After the former is 10 withdrawn from the composition, the first layer is allowed to stand and dry or is dried in an oven at 70°C for about 3 minutes to form a coherent film or layer. Once dried, the first layer is capable of inducing conventional coagulation when dipped or immersed into a 15 latex compound.

After the formation of the first layer, the former is then dipped into a latex compound to form a second layer. The latex compound can be any coagulatable natural or synthetic latex compounds, coagulatable 20 natural or synthetic rubber latices or styrenic block copolymer dispersions known in the art. Conventional formulations for the preparation of latex are well known in the art and those skilled in the art are readily able to vary the formulations and conditions of 25 curing and the like to suit the particular latex being used as well as the final article desired. Precured

or partially cured latex can be used; however, if non-cured latex is used, it must be cured after forming. Additionally, the latex may contain conventional compounding ingredients commonly utilized. Specific 5 examples are provided in U.S. Patent 3,411,982, hereby incorporated by reference.

When the former is immersed into the latex compound, the dried film induces coagulation of the latex to produce a uniform coagulated deposit of the 10 latex on the former. The length of time the former is immersed in the latex determines the wall thickness of the article. The longer the dwell time period, the greater the wall thickness of the article, and vice versa. Articles produced according to the method of 15 this invention typically have a thickness of between 4 to 15 mils.

The former is removed from the latex with a coating of gelled latex adhering to it. The former is placed in a water bath to leach out water soluble 20 components such as proteins, electrolytes, etc. The temperature of the water bath is between 49-60°C.

After leaching, the second layer maybe dried or coated with a lubricating polymer. If dried, then the first and second layers are cured. As used in this 25 invention, the term "curing" also includes "fusing" or "fusion" as some types of polymers require fusing instead of curing. For example, thermoplastic

elastomers such as the copolymers poly(styrene-b-isoprene-b-styrene) (SIS), poly(styrene-b-butadiene-b-styrene) (SBS), and poly(styrene-b-ethylene propylene-b-styrene) (SEPS) require fusing. Typically, however, 5 curing is employed. The length of time required for curing depends upon the polymers selected, however, most polymers can be cured in about 5 to 10 minutes at about 138°C. After curing, the resulting article is allowed to cool and is removed from the former.

10 The acrylic ester latices when used as article coatings can be applied either before the drying of the second layer, after the drying of the second layer but before curing, or after curing. When applied, it will add additional layers to the already multi-layered 15 article. After the acrylic ester latex is coated to the article, it is allowed to stand and dry or is dried in an oven. One skilled in the art would recognize that the conditions required for drying the lubricating polymer in an oven vary based on the type of 20 lubricating polymer employed. If the acrylic ester polymer is added to the article prior to curing, the polymer may be dried and the article cured in one step. If the polymer is applied after the article is cured, then it must be dried.

25 Stripping of the article from the former turns the article inside out so that the first layer is on the outside and the latex or lubricating layer is on the

inside. The stripping process does not require any powder to release the article from the former. Additionally, the resultant article is not tacky. The process of this invention results in multi-layered 5 powder-free rubber articles. Examples of the types of articles that can be made pursuant to this invention include: surgical and examination gloves, catheters and condoms.

In the practice of the invention with respect to 10 gloves, the molds used are in a variety of sizes and shapes corresponding to the various hand sizes for which the gloves are intended. The preferred mold is a contoured mold having a textured to highly polished ceramic or porcelain surface or one having a 15 fluorocarbon coating, however, other molds such as glass, hard woods, and plastic can also be used. Gloves produced according to this method are easily removed from a former are not tacky, exhibit good donning characteristics, and are powder-free.

20

BENEFITS OF THE INVENTION

Articles produced according to this invention have 25 many features and benefits. For example, articles made according to this invention can be made in a continuous fashion with significant economic savings as compared to the conventional processes used to make powder-free articles. The conventional processes used

to make powder-free articles are more expensive due to the number of chlorination, turning and drying steps involved in the manufacture.

A further advantage of this invention is that the 5 process uses environmentally friendly materials.

Unlike other processes used to make powder-free gloves, the process of this invention does not include a chlorination step. Chlorine is considered a toxic chemical and the use of a chlorination process to 10 remove powder from a rubber article raises numerous disposal and environmental issues. In addition, chlorinated products tend to discolor and age poorly both in storage and in use.

#### EXAMPLES

15 The following examples could be tried to demonstrate the process claimed in the aforementioned applicaiton. A coagulation inducing film could be deposited onto a former (ceramic or Halar) from an emulsion acrylic copolymer (e.g., Hycar 26256), diluted 20 with water to 6% by weight copolymer. This emulsion would be stabilized with a non-ionic surfactant so that the addition of calcium nitrate (20 wt%) does not destabilize the acrylic emulsion. The level of non- 25 ionic surfactant could be selected in the preferred range from 0.5 wt% to 6 wt.% , so that the emulsion does not destabilize during the addition of calcium

nitrate. The Hycar 25256 is manufactured by BF Goodrich and is understood to contain a copolymer of either acrylic or methacrylic acid of about 5% or more by weight with a lower alkyl acrylate ester (C<sub>1</sub> to C<sub>4</sub>).

5 This material has a TG of + 45°C.

A silicone emulsion Dow Corning 365 could be added in an amount of approximately 1% by wt. to facilitate release from the mold.

10 The coagulation inducing film on the former after drying could be dipped into the latex compound in a customary fashion to distribute the film uniformly around the former. The deposited coagulated film could be leached in warm water and a donning layer could be applied. It is expected a former treated with the 15 acrylate latex described above would show a 20% improvement in mold release. When combined with the silicone it is expected a 30% or more increase would be shown in mold release.

#### CONCLUSION

20 Although the invention has been described primarily in connection with the special and preferred embodiments, it will be understood that it is capable of modification without departing from the scope of the invention. The following claims are intended to cover 25 all variations, uses, or adaptions of the invention,

following, in general, the principles thereof and including such departures from the present disclosure as come within known or customary practice in the field to which the invention pertains, or as are obvious to 5 persons skilled in the field.

## I CLAIM:

1. A multiple dip process for making powder-free rubber articles comprising the steps of:

5       a) dipping a former of the desired shape of the article into a composition consisting essentially of an aqueous acrylic ester latex and water soluble salts capable of coagulating a rubber latex whereby a first layer lubricating coating is formed on the former;

10      b) dipping the former treated in step (a) into a rubber latex to produce a second layer;

      c) leaching the second layer in water;

      d) curing the first and second layers; and

      e) striping the resultant article from the former.

15      2. A multiple dip process for making powder-free rubber articles comprising the steps of:

20      a) dipping a former of the desired shape of the article into a composition consisting essentially of an aqueous acrylic ester latex whereby a first lubricating coating is formed on the former;

      b) dipping the former treated in step (a) into water soluble salts capable of coagulating a rubber latex;

      c) dipping the former treated in step (b) into a rubber latex to produce a second layer;

d) leaching the second layer in water;  
e) curing the first and second layers; and  
f) stripping the resultant article from the former.

5

3. The multiple dip process of claims 1 or 2 which comprises the additional step of applying the composition which does not contain the water soluble salts to the second layer prior to curing.

10

4. The multiple dip process of claims 1 or 2 where which comprises the additional step of applying the composition which does not contain the water soluble salts to the article prior to stripping, but after curing, and then drying the composition.

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5. The multiple dip process of claims 1 or 2 where the aqueous acrylic ester latex is an acrylic acid or methacrylic acid ester latex which contains from 4 to 22 carbon atoms.

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6. The multiple dip process of claim 5 where the aqueous acrylic ester is a copolymer which contains from 2-3 monomers.

7. The multiple dip process of claims 1 or 2 where the aqueous acrylic ester latex is a mixture of acrylic esters.

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8. A multiple dip process for making powder-free rubber gloves comprising the steps of:

a) dipping a former of the desired shape of the

glove into a composition consisting essentially of an aqueous acrylic ester latex wherein the acrylic ester is an acrylic ester containing from 0.1-20 weight percent of either acrylic acid or methacrylic acid and water soluble salts capable of coagulating a rubber latex whereby a first layer lubricating coating is formed on the former;

5 b) dipping the former treated in step (a) into a rubber latex to produce a second layer;

10 c) leaching the second layer in water;

d) curing the first and second layers; and

e) striping the resultant article from the former.

9. A multiple dip process for making powder-free rubber articles comprising the steps of:

15 a) dipping a former of the desired shape of the article into a composition consisting essentially of an aqueous acrylic ester latex wherein the acrylic ester is an acrylic ester containing from 0.1-20 weight percent of either acrylic acid or methacrylic acid

20 whereby a first layer, lubricating coating is formed on the former;

b) dipping the former treated in step (a) into water soluble salts capable of coagulating a rubber latex;

25 c) dipping the former treated in step (b) into a rubber latex to produce a second layer;

d) leaching the second layer in water;

e) curing the first and second layers; and  
f) stripping the resultant article from the  
former.

10. The multiple dip process of claims 8 or 9 which  
5 comprises the additional step of applying the  
composition which does not contain the water soluble  
salts to the second layer prior to curing.

11. The multiple dip process of claims 8 or 9 where  
which comprises the additional step of applying the  
10 composition which does not contain the water soluble  
salts to the article prior to stripping, but after  
curing, and then drying the composition.

12. The multiple dip process of claims 8 or 9 where  
the aqueous acrylic ester latex is an acrylic acid or  
15 methacrylic acid ester latex which contains from 4 to  
22 carbon atoms.

13. The multiple dip process of claim 12 where the  
aqueous acrylic ester is a copolymer which contains  
from 2-3 monomers.

20. The multiple dip process of claims 8 or 9  
where the aqueous acrylic ester latex is a mixture of  
acrylic esters.

15. A multiple dip process for making powder-free  
rubber gloves comprising the steps of:

25 a) dipping a former of the desired shape of the  
glove into a composition consisting essentially of an  
aqueous acrylic ester latex, water soluble salts

capable of coagulating a rubber latex and from 0.001-3% by weight of a silicone resin whereby a first layer lubricating coating is formed on the former;

5                   b) dipping the former treated in step (a) into a rubber latex to produce a second layer;

                  c) leaching the second layer in water;

                  d) curing the first and second layers; and

                  e) striping the resultant article from the former.

10                 16. A multiple dip process for making powder-free rubber gloves comprising the steps of:

15                 a) dipping a former of the desired shape of the glove into a composition consisting essentially of an aqueous acrylic ester latex and from 0.001-3% by weight of a silicone resin whereby a first layer lubricating coating is formed on the former;

                  b) dipping the former treated in step (a) into a rubber latex to produce a second layer;

                  c) leaching the second layer in water;

20                 d) curing the first and second layers; and

                  e) striping the resultant article from the former.

25                 17. The multiple dip process of claims 15 or 16 which comprises the additional step of applying the composition which does not contain the water soluble salts to the second layer prior to curing.

18. The multiple dip process of claims 15 or 16

where which comprises the additional step of applying the composition which does not contain the water soluble salts to the article prior to stripping, but after curing, and then drying the composition.

5 19. The multiple dip process of claims 15 or 16 where the aqueous acrylic ester latex is an acrylic acid or methacrylic acid ester latex which contains from 4 to 22 carbon atoms and the silicone resin is in the form of an aqueous emulsion.

10 20. The multiple dip process of claim 19 where the aqueous acrylic ester is a copolymer which contains from 2-3 monomers.

15 21. The multiple dip process of claim 15 or 16 where the aqueous acrylic ester latex is a mixture of acrylic esters.

22. A former for making powder-free rubber articles which contains a coating of the composition described in claims 1 or 2.

20 23. A former for making a powder-free rubber gloves which contains a coating of the composition described in claims 8 or 9.

24. A former for making a powder-free rubber gloves which contains a coating of the composition described in claims 15 or 16.

25 25. A rubber glove having its inner surface coated with the composition described in claim 3.

26. A rubber glove having its inner surface coated

with the composition described in claim 10.

27. A rubber glove having its inner surface coated with the composition described in claim 17.

# INTERNATIONAL SEARCH REPORT

Int'l. Application No  
PCT/US 96/01816

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 6 B29C41/00 B29C41/14 B29C41/22

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 B29C B29D B29H A61B A41D A61F C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- 'A' document defining the general state of the art which is not considered to be of particular relevance
- 'E' earlier document but published on or after the international filing date
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- 'O' document referring to an oral disclosure, use, exhibition or other means
- 'P' document published prior to the international filing date but later than the priority date claimed

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- 'X' document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- 'V' document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- '&' document member of the same patent family

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## INTERNATIONAL SEARCH REPORT

Int'l Application No  
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